

**16-17 NOVEMBER 2015, ONERA, PALAISEAU-FRANCE**  
**<http://microscope.onera.fr>**

## **MICROSCOPE Science Mission Center Status**

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***on behalf of the MICROSCOPE team***

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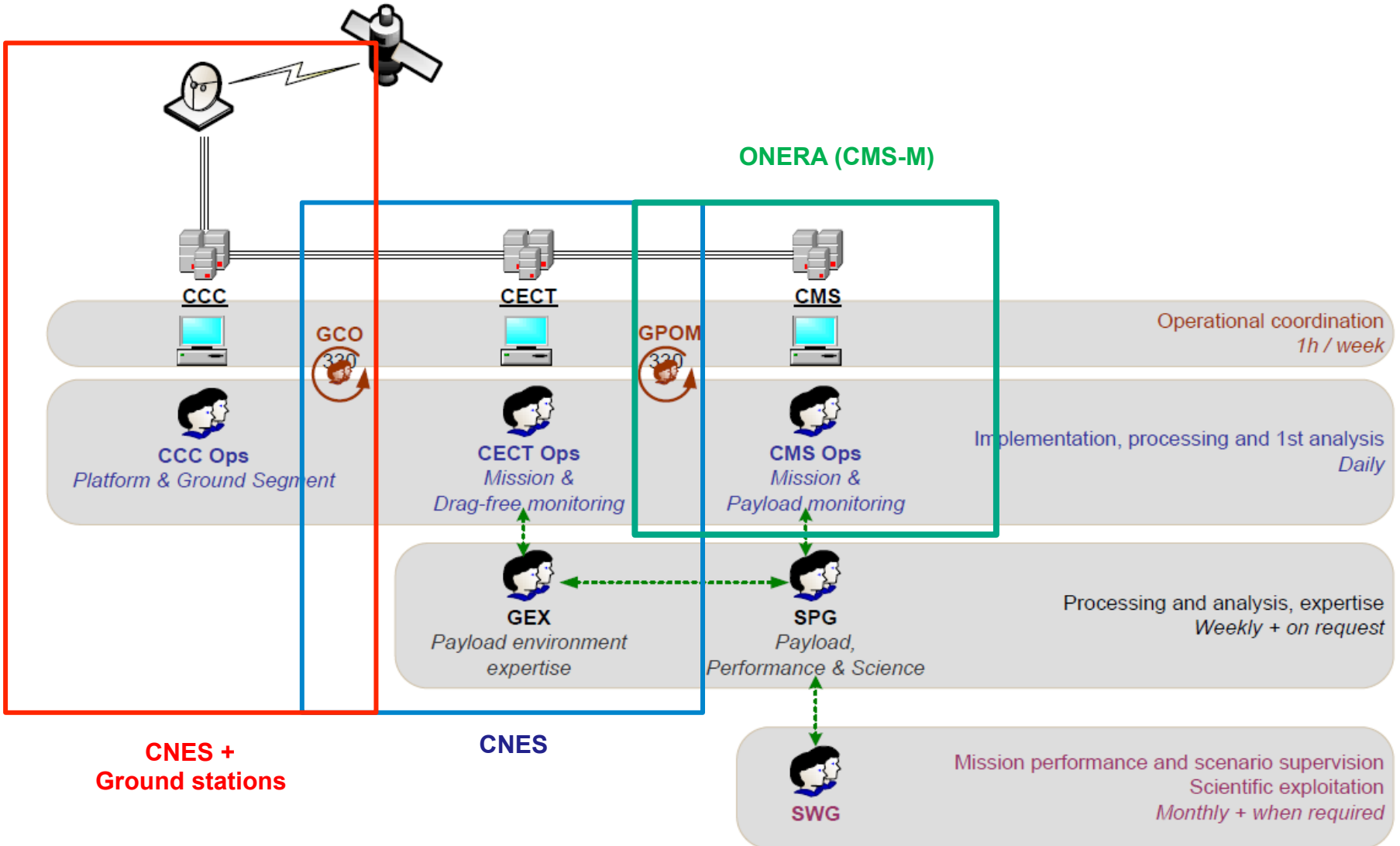
retour sur innovation



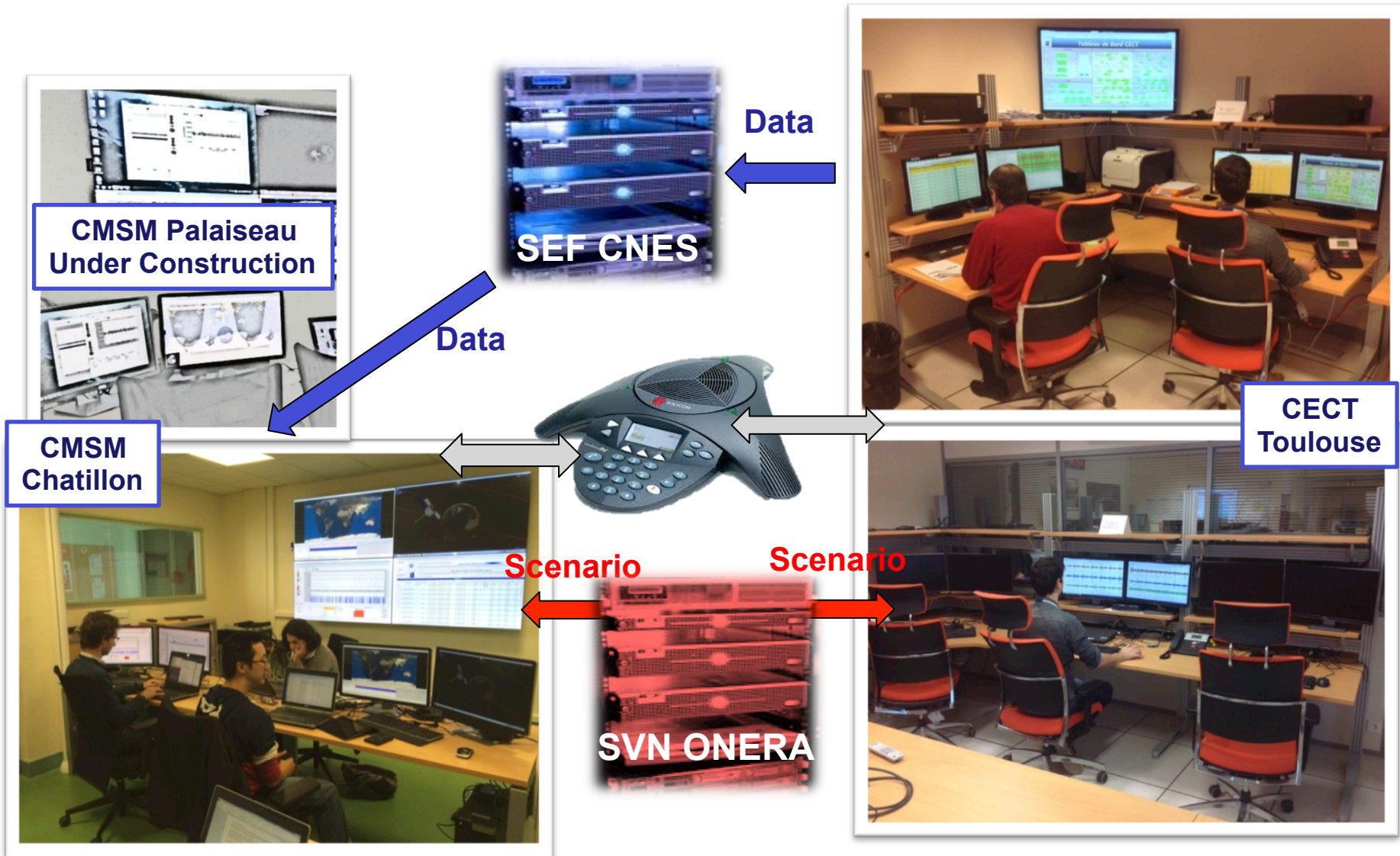
- The Science Mission Center : description
- Participation to the qualification of the ground segment
- Some results of the qualification
- The road still ahead

- **CNES**
  - **CCC** : Mission Control Center ➔ ground station mngt / on board survey / s/c programmation
  - **CECT**: interface between CMS and CCC ➔ converts the mission scenario into s/c commands, s/c performance survey, prepares the raw data for the CMS
  - **GCO** : Group of coordination of Control Operations
  - **GPOM** : Group of Mission Operations ➔ meets each Tuesday
  - **GEX**: Group of Experts ➔ generates the precise s/c orbit or attitude data
- **ONERA**
  - **CMS**: Science Mission Center ➔ Mission scenario / Science data process / payload survey / Publication
  - Collaboration with OCA on data process with contribution of ZARM
  - Participation to GPOM, **SPG** (Performance Group), **SWG** (Science Working Group)

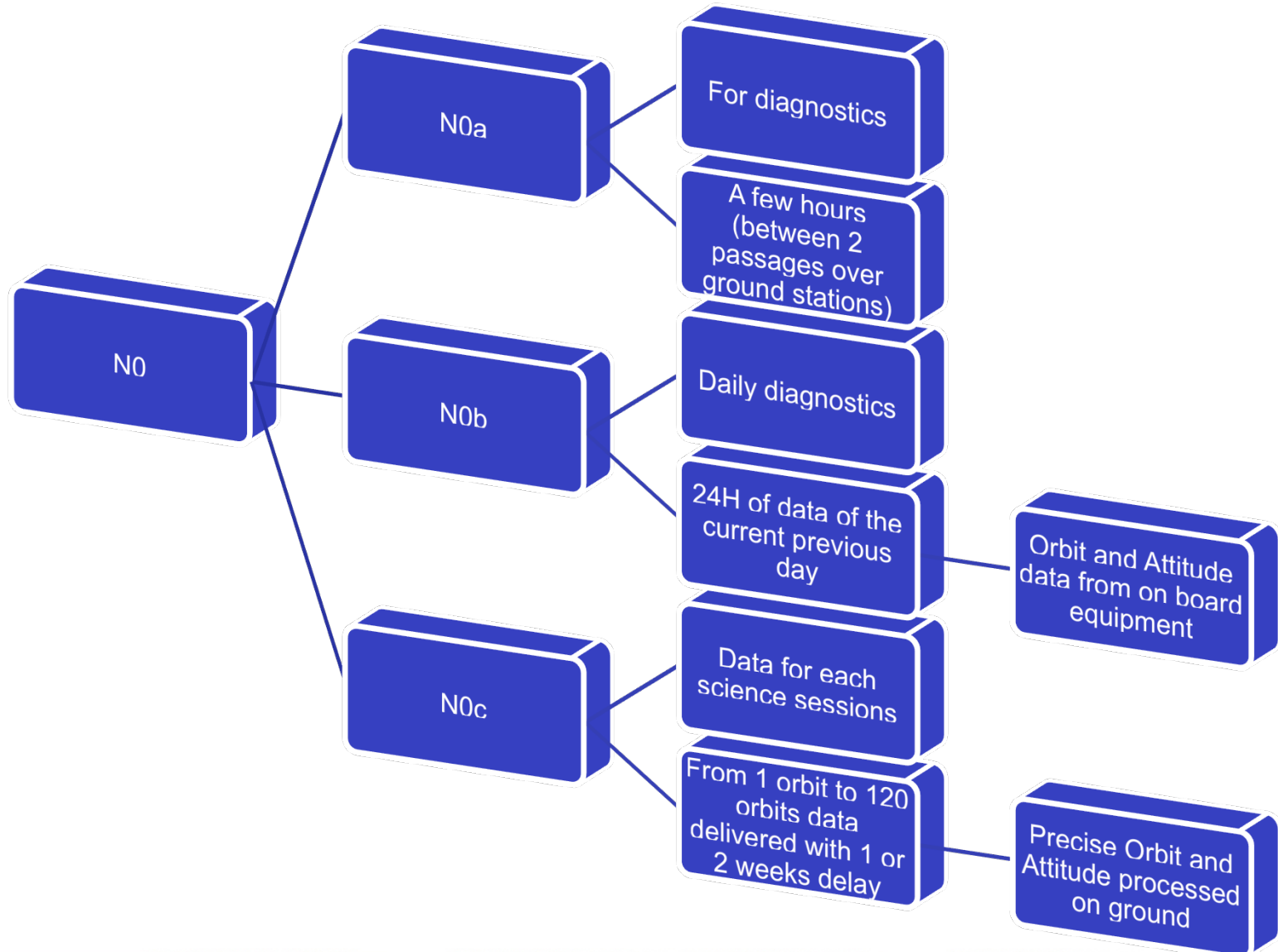
# MICROSCOPE GROUND SEGMENT



# Daily and weekly exchanges



# N0 DATA LEVEL PROVIDED BY CNES



# Downlink flux of data (N0 is converted)



**ASCII → BIN**

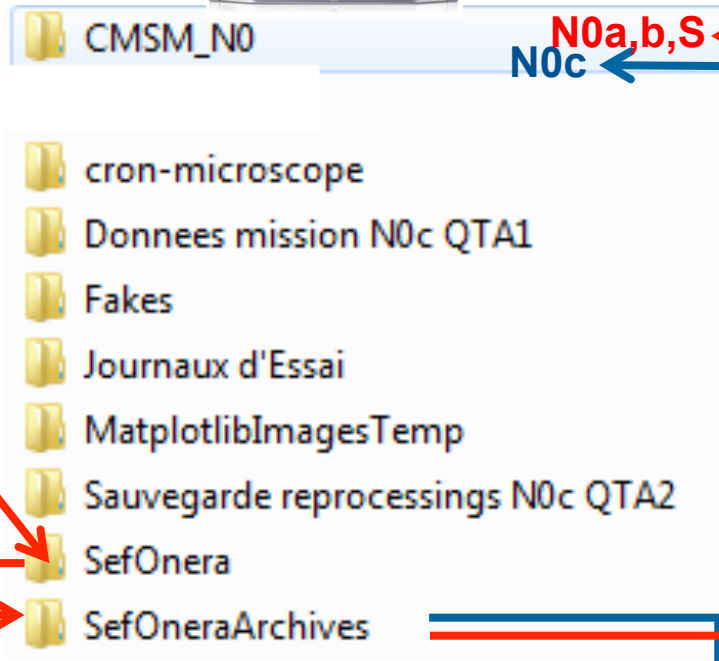
**CMSM - softwares**  
CpySef2SefO  
LPDN

CMSM-N0.ONERA



SEF CNES

**CpySef2SefO**



N0a,b,S  
N0c

**LPDN**

- AccelerationPhi.bin
- AccelerationPsi.bin
- AccelerationTheta.bin
- AccelerationX.bin
- AccelerationXscaa.bin
- AccelerationY.bin
- AccelerationZ.bin
- PositionPhiRad.bin
- PositionPsiRad.bin

MIC\_CECT\_N0i\_TSAGE\_<st\_date>\_<cre\_date>.tgz  
MIC\_CECT\_N0i\_PL\_<st\_date>\_<cre\_date>.tgz  
MIC\_CECT\_N0i\_MISSION\_<st\_date>\_<cre\_date>.tgz

CMSM-N1N2.ONERA



N1a

- CMSM\_N1
- CMSM\_N2

ONERA

THE FRENCH AEROSPACE LAB

# The *TSAGE* Package



	N° APID	Télémessure (mnémonique)	Description
<b>DFACS mode</b>	4	PMODESAT	Télémessure permettant de connaître le mode de mesure mode scaa
<b>Star Sensor, Commands to CGPS</b>	108	MNORTE1	Télémessure donnant les quaternions d'attitude et les vitesses angulaires estimées
	109	MNORTE2	Télémessure donnant les biais d'accélération angulaire, les torseurs de commande et les commandes moteur.
<b>Memory Dumps</b>	402 et 403	DUMPARBO	Dump par bloc des paramètres des lois de commande par défaut stockés en EEPROM ICU-REF ou ICU-EP
	404 et 405	DUMPARTO	Dump complet de tous les paramètres stockés en EEPROM ICU-REF ou ICU-EP
	406 et 407	DUMPARAT	Dump d'un bloc de paramètres de la table d'attente ICU-REF ou ICU-EP
	408 et 409	DUMPARCU	Dump d'un bloc de paramètres de la table courante ICU-REF ou ICU-EP
<b>Sensor Measures (Acc, Temp, Volt, Pos...)</b>	410 et 411	ACCTM	ACC_4Hz : TM Science à 4 Hz ICU-REF ou ICU-EP <b>FOR EP TEST</b>
	412 et 413	TMHK	TM_HK :TM House Keeping à 1 Hz ICU-REF ou ICU-EP
<b>Software state</b>	414 et 415	AUTOTS	TM de l'Autotest ICU-REF ou ICU-EP
	430 et 431	TMACKICU	TM d'acquiescement à une commande de I ICU-REF ou ICU-EP.
	1470	EIFCU	TM Anomalie ICU



# The *MISSION* Package

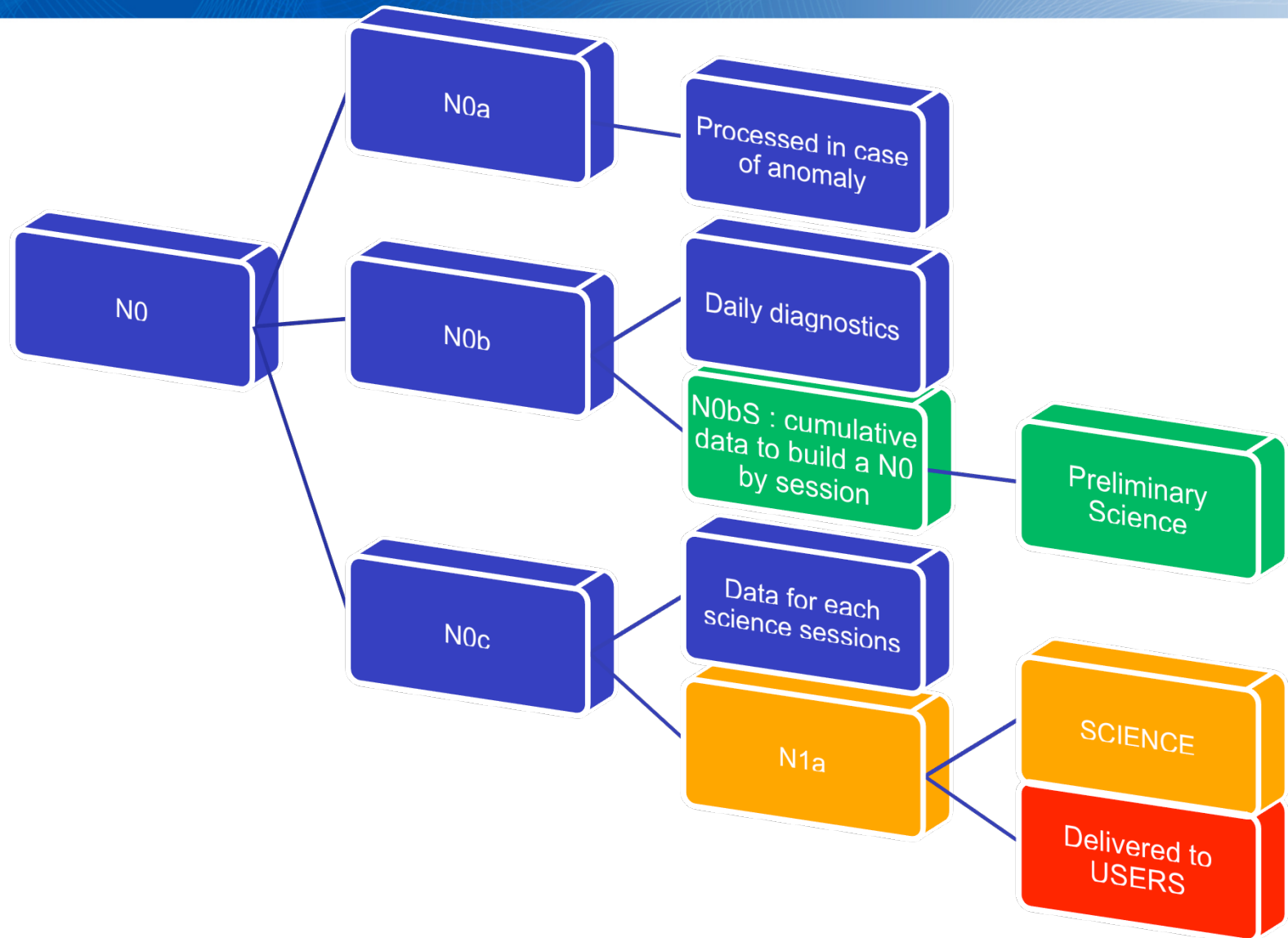
*N0b level is converted in Bin. N0c is not converted (Ascii)*



APPLICABLE	NAME	TYPE
N0b	ORBIT_EVENTS	Events from orbit, ground stations, ...
N0b	PREDICTED_ORBIT	Predicted ephemerides
N0b	DETERMINATED_ORBIT	Ephemerides determined on ground from s/c data
N0c	PRECISE_ORBIT	Fine Ephemerides determined by specific processing <b>FOR EP TEST</b>
N0c	PRECISE_ATTITUDE	Fine attitude restitution by specific processing <b>FOR EP TEST</b>
N0c	HKTM_TROUS	Holes of Telemetry
N0b	HEALTH_MONITORING	s/c monitoring report
N0c	ZOOMIC_PERFO_REPORT, ORAMIC_PERFO_REPORT,	Expert reports of performance
N0c	ZOOMIC_EXP_REPORT, ORAMIC_EXP_REPORT	Expertise from tools of CECT

- Contains all other data :
  - s/c housekeeping
  - Equipement data
  - S/C Softwares status
  - Propulsion data
  - ....
- Not processed in CMSM
- Stored in their original format

# N0 DATA PRODUCED BY CMSM



# Uplink flux of data

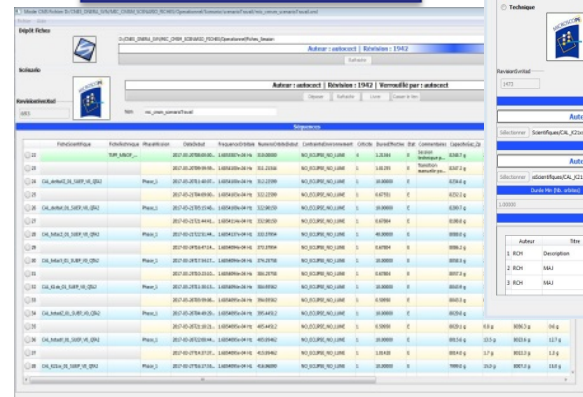


**CMSM - softwares**  
**Scenario Editor**  
**Session Editor**

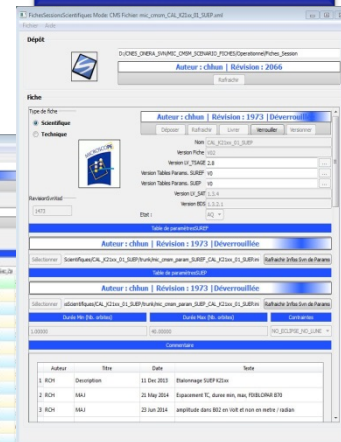


**SVN ONERA**

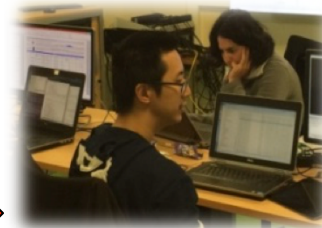
**Scenario Editor**



**Session Editor**



**CNES**



**ONERA**

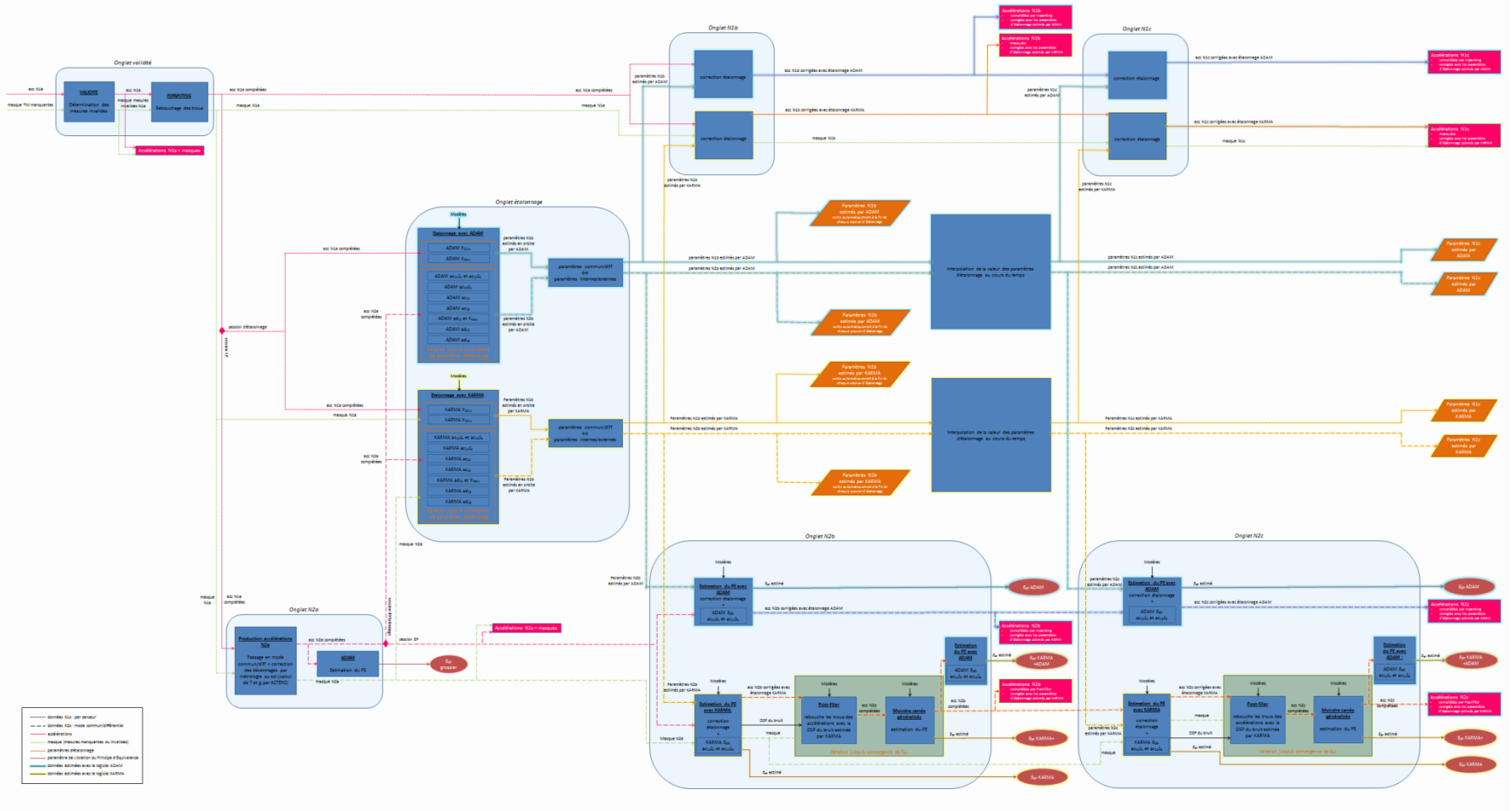


**DATABASE OF XML FILES**

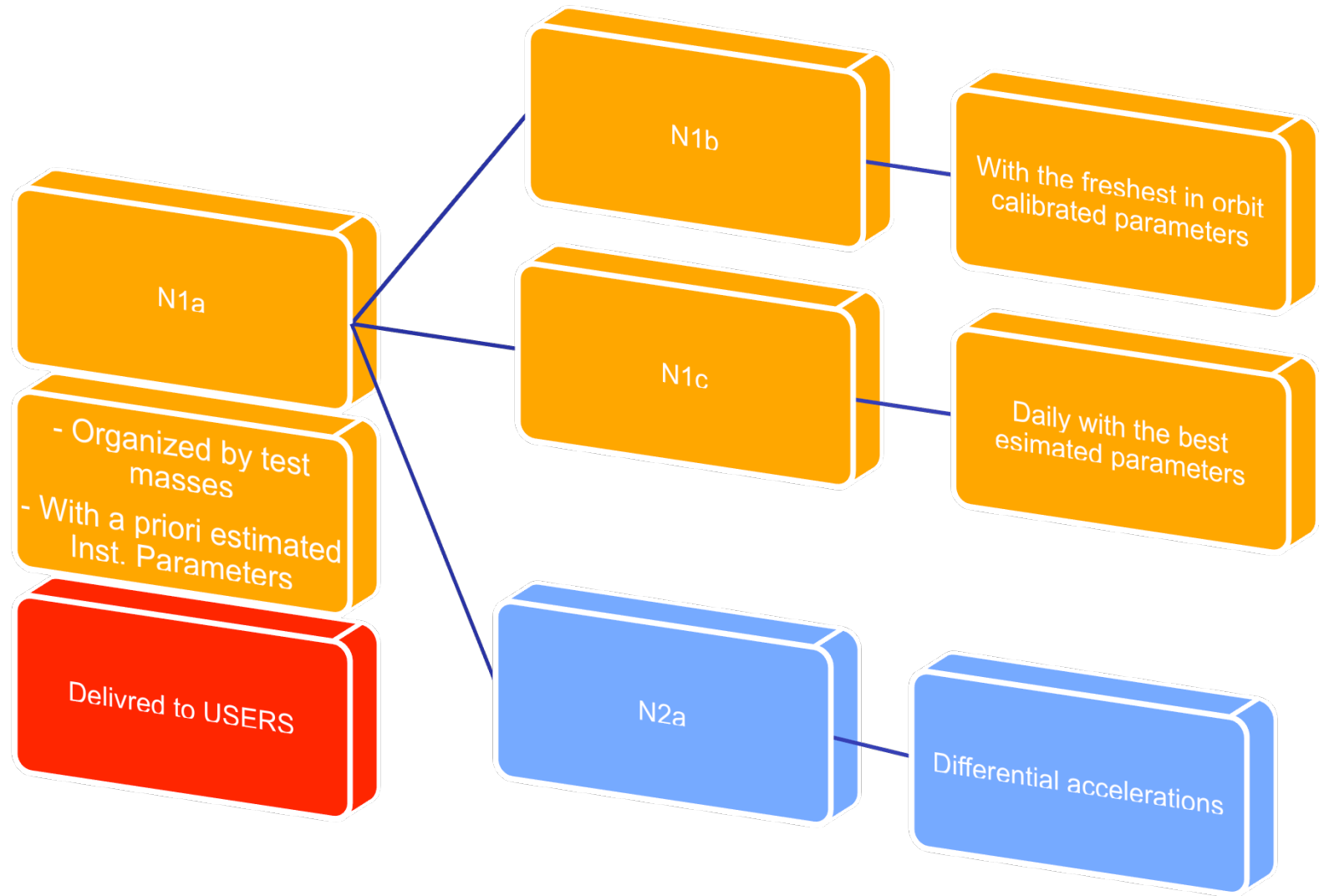
# SCIENCE WORKFLOW (see E. Hardy slides) N1 & N2 data level



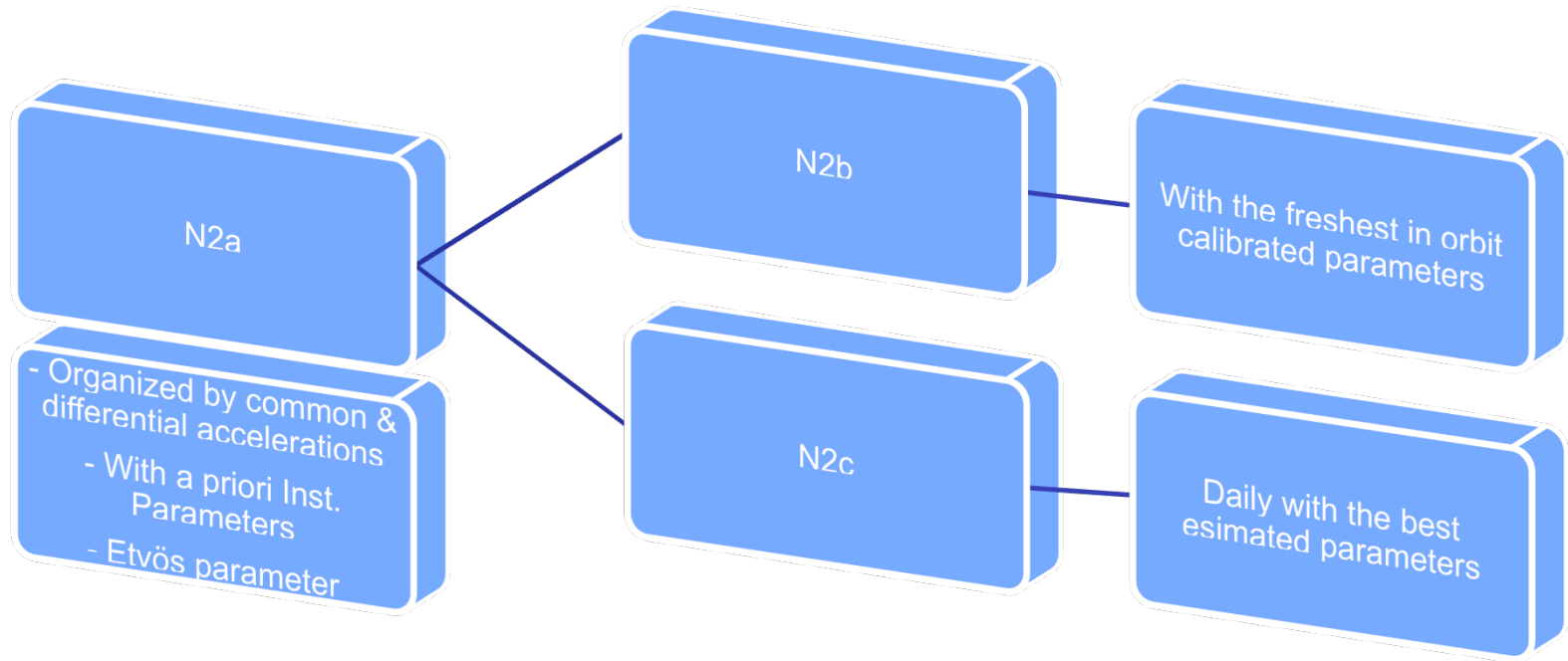
Quentin BAGHI, Joël BERGÉ, Patrice CARLE, Rajana CHHUN, Emilie HARDY Stéphanie LALA, Manuel RODRIGUES, Pierre TOUBOUL



# N1 DATA PRODUCED BY CMSM



# N2 DATA PRODUCED BY CMSM



- The Science Mission Center : description
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# Technical Qualification (QT in french) of the MICROSCOPE Science Mission Center



Test of the interfaces on formats and procedures: from the ground segment to the on board equipment

Some equipment are simulated (antennas, payload,...) as well as the s/c environment  
Some equipment are real hardware (OBC, DSP card of the payload,...)  
=> END TO END simulator 1ms (payload) to 2 weeks (inertial session fo EP)

Test of the data processing on the compliance to the specs:

For operational tools (scenario, session form edition, diagnostics and analysis)

V1 (partially ope.) beginning of 2015



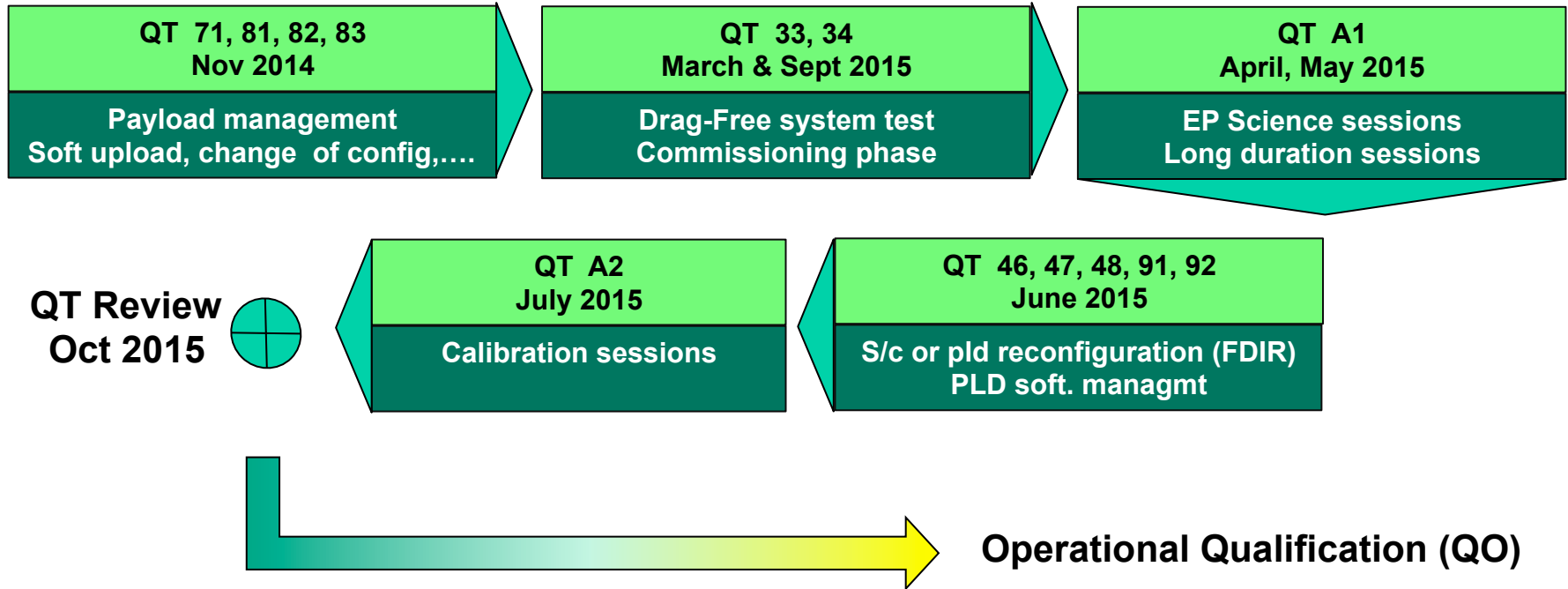
V2 (1<sup>st</sup> oper. Version) – for Operational Qualification NOV 2015

For Science tools (LPDS)

Simulated parameters + Etvos parameter hidden in the data by CNES

=> The data process should recover the hidden numbers with accuracy (see preliminary results)

# Technical Qualification (QT in french) of the MICROSCOPE Science Mission Center



**QT xx = Test folder defining :**

- the obj. and expected results
- the means
- the perimeter of qualification

Référence	μGN-SYS-QT-34
Titre	De la LEOP au 1 <sup>er</sup> drag-free
Classe	Opérabilité du Satellite et du segment sol par le CCC : Lancement – début de vie
Objectifs	Idem QT-33 avec des anomalies qui pourront être forcées aux niveaux suivant : <ul style="list-style-type: none"> <li>- Déblocage des masses, fil d'or et mise en lévitation</li> <li>- Invalidités ou mesures aberrantes T-SAGE</li> <li>- Efficacité propulseurs</li> <li>- Dialogue avec l'électronique propulseur</li> </ul>
Moyens de test	CCC BVSS + SUSON CECT CMSM (en version nomade sur site CNES)
Contexte	Après l'essai QT-33
Délégation	Cf. DA1

## Preliminary results on QTA2 (Calibration Phase) with the LPDS Tool



- Realised without precise orbit and attitudes or partial data
- No processing of data lacks here

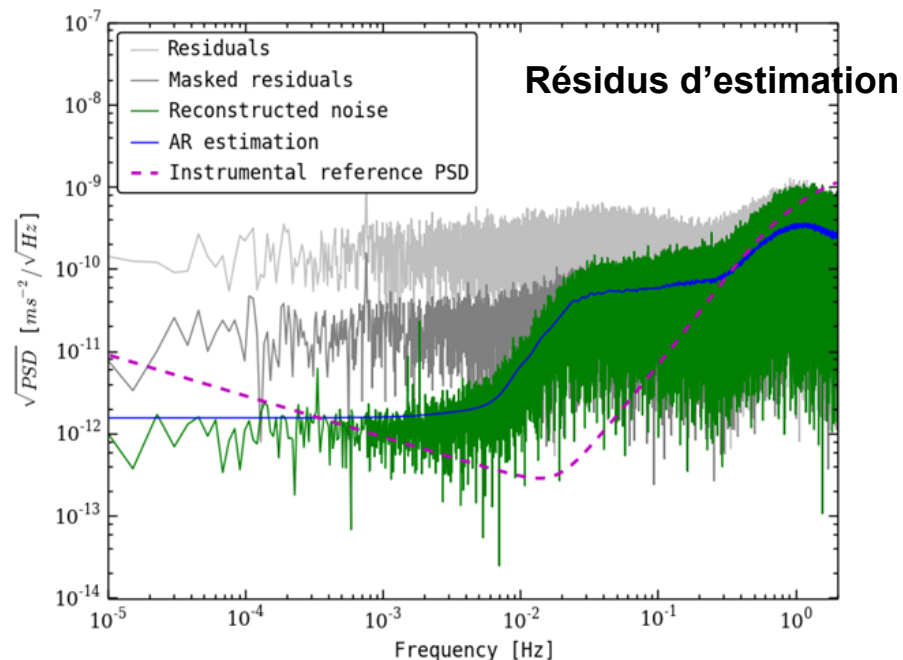
Paramètre	Estimation	Remarque
$a_{c11}\Delta_x$	-40,845 $\mu\text{m}$	estimé sur 7 orbites seulement car données d'orbite manquantes
$a_{c11}\Delta_z$	17,195 $\mu\text{m}$	estimé sur 7 orbites seulement car données d'orbite manquantes
$a_{c11}\Delta_y$	32,11 $\mu\text{m}$	
$a_{d11}'$	0,00742	
$a_{d12}$	0 rad	non inclus dans le run-loop car résultat aberrant – en cours d'investigation
$a_{d13}$	0 rad	non estimé car données d'orbite manquantes
$a_{c12}$	-16,362 mrad	
$a_{c13}$	21,392 mrad	
$K_{2dxx}$	5285,5 $\text{s}^2/\text{m}$	
$\delta_{EP}$	$-94 \cdot 10^{-15}$	estimé sur 7 orbites seulement au lieu de 120

# Analyse de la QTA1 : résultats préliminaires (Quentin Baghi)



## Estimation des décentrages par méthode KARMA avec:

- données N0c session 6 EPR SUEP, accélération différentielle selon X
  - orbite et attitude précises
- pas d'autre étalonnage disponible au moment de l'analyse (limite la perfo sur  $\delta$ )
- analyse effectuée « en aveugle » (pas de connaissance préalable des valeurs réelles)



Parameters	Expected Values	Valeur estimée	Incertitude statistique estimée
$a \downarrow c_{11} \Delta \downarrow x$	-39,60 $\mu\text{m}$	-39,78 $\mu\text{m}$	0,014 $\mu\text{m}$
$a \downarrow c_{11} \Delta \downarrow z$	19,80 $\mu\text{m}$	19,83 $\mu\text{m}$	0,014 $\mu\text{m}$
$\delta$	?	4,38e-15	2,6e-15

Erreur sur les décentrage de l'ordre de 0,1 $\mu\text{m}$ , en accord avec l'erreur analytique avant re-processing prévue dans le plan d'étalonnage : MIC-DC-S-7-TS-5075-ONE

# Operational Qualification (QO) of the MICROSCOPE Science Mission Center

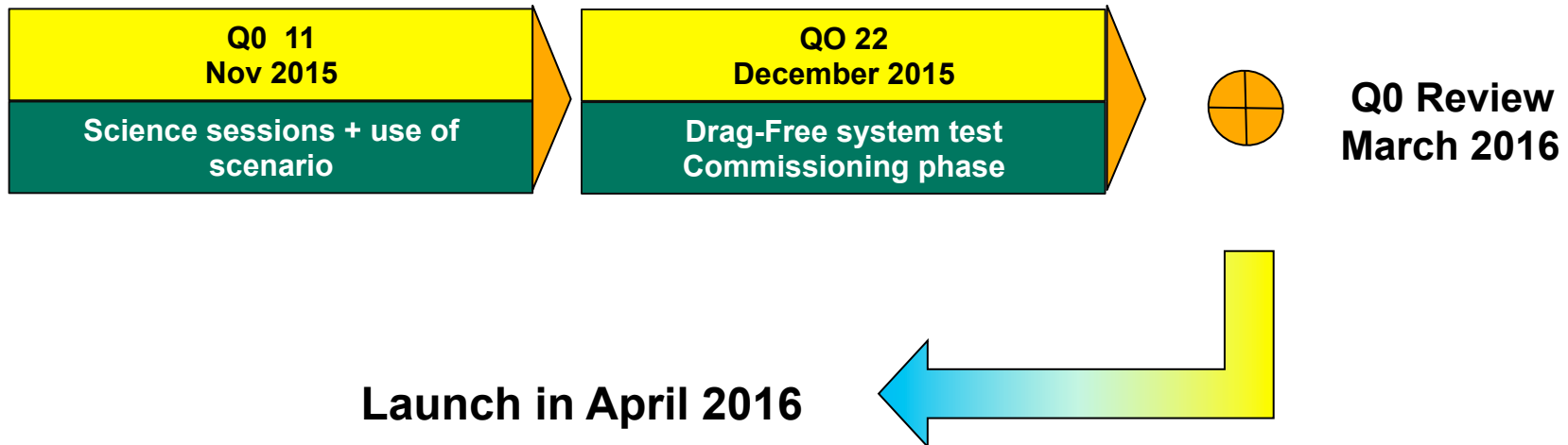


## Objectives:

Test of the interfaces : the same as QT but with real time chronology of the operations (people, hardware, software)

Simulated Scenario : launch in August 2015

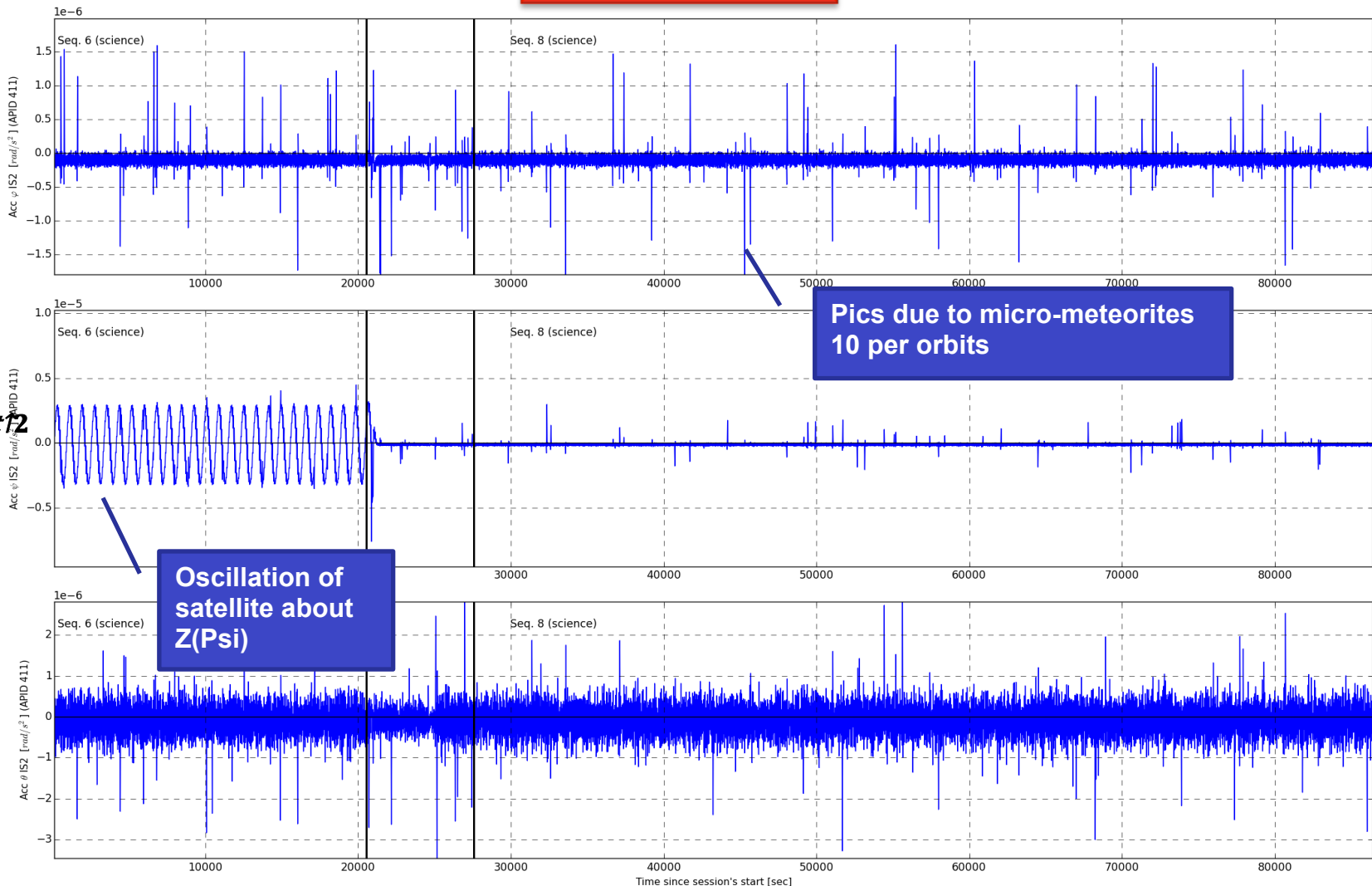
Test of the data processing : V2 (1<sup>st</sup> oper. Version) => VF (flight version)



# QO-11 : N0B DATA: Exemple of Acc. Measurements transition between 2 calibration



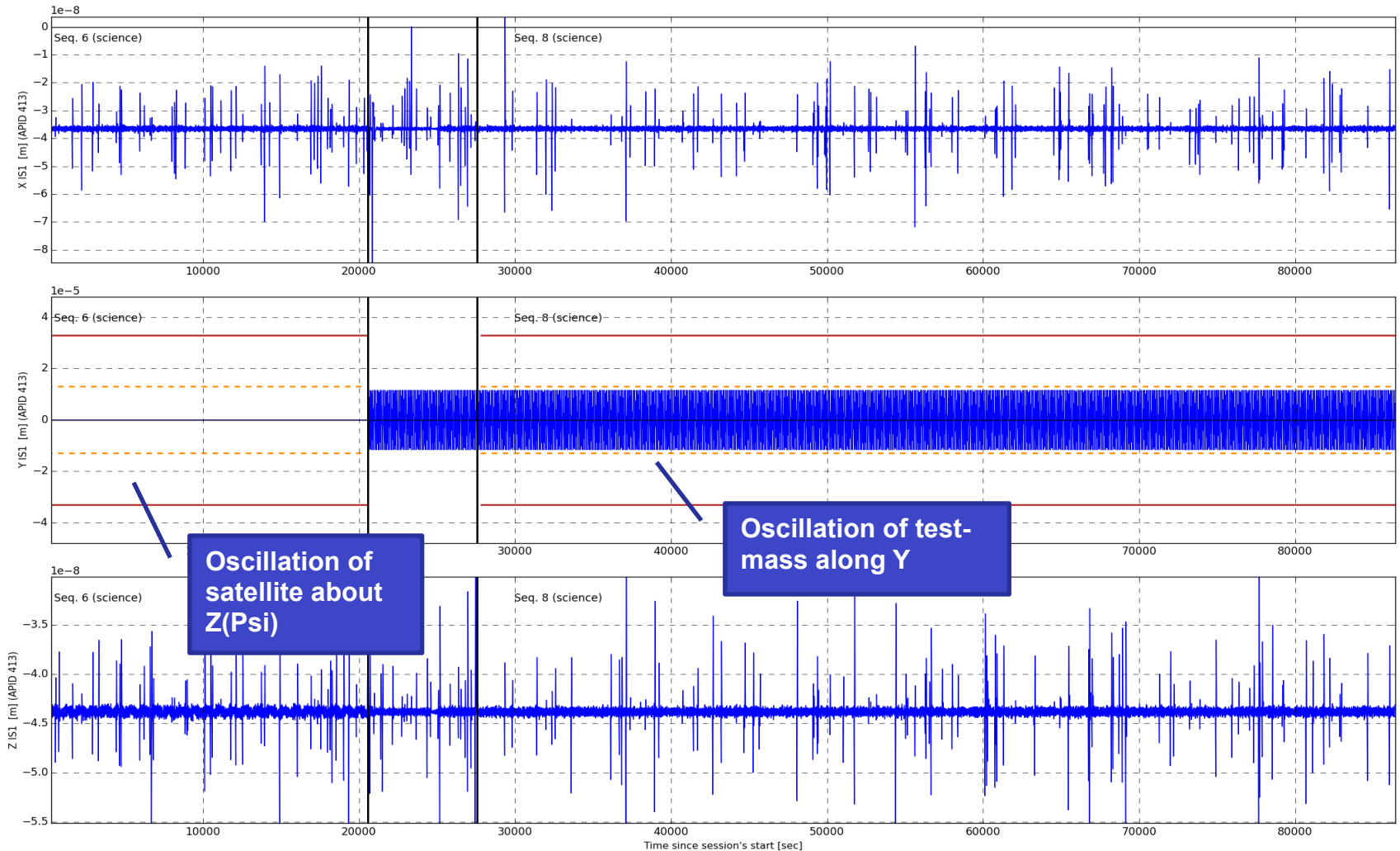
10<sup>th</sup> of November 2015



# QO-11 : N0B DATA: Exemple of Acc. Measurements transition between 2 calibration



10<sup>th</sup> of November 2015



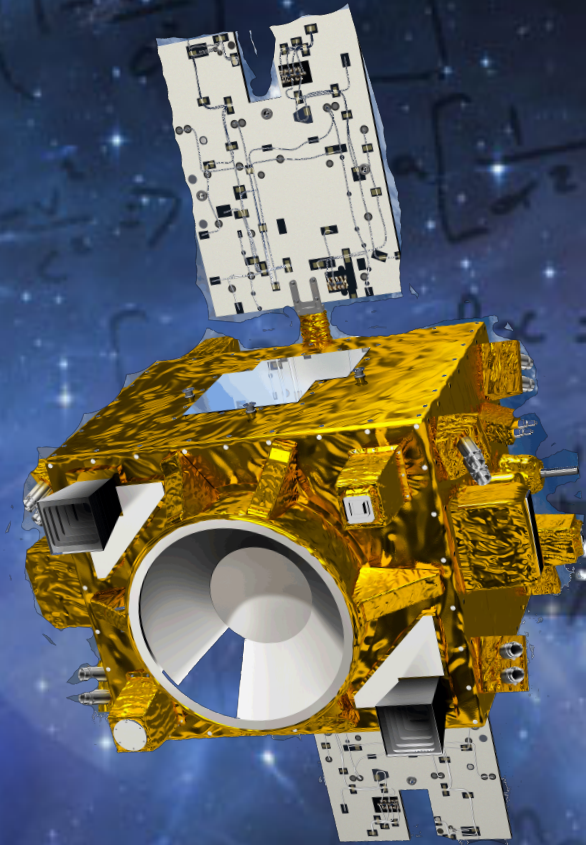
- **Satellite:**
  - Thermal vacuum test performed in October 2015
  - End of integration in November
  - Vibration and acoustic tests in December
  - Travel to Kourou in February 2016
- **Science Mission Center:**
  - QO tests until mid december
  - January – March 2016:
    - Data processing of all simulated data
    - Improvement of software tools
    - Finalization of LPDS with 2 methods of filling holes in data
  - Review of Qualification and Review to Authorize the flight



# THANK YOU FOR YOUR ATTENTION



## CMS-M TEAM



*With the clever contribution of Quentin Baghi (PhD)*